THE TELEGRAPHIC JOURNAL.

Vol. II.—No. 31.

PRELIMINARY EXPERIMENTS ON A MAGNETISED COPPER WIRE.*

By Prof. BALFOUR STEWART, M.A., LL.D., F.R.S., and ARTHUR SCHUSTER, Ph.D.

1. The following experiments were made in the Physical Laboratory of Owens College, Manchester. The copper wire employed was found to contain no perceptible trace of iron, nor was it sensibly magnetic, behaving quite in a neutral manner when tested by the highest magnetic power at our disposal. It was covered with gutta-percha. The diameter of the wire was 0·0487 inch. The wire was wound fifty-three times in one direction round the poles of a powerful electro-magnet, the length of wire encircling these poles being about 12 metres. The direct distance of the magnet from the galvanometer was about 12 metres.

A Wheatstone bridge was employed, and a very delicate Thomson's reflecting galvanometer by Elliott Brothers, of which the resistance was 5540 B.-A. units. A circuit-breaker was placed in the circuit close to the bridge. On some occasions we used one consisting of a solid key which might be removed, thus breaking the circuit; but on other occasions a fluid or mercurial circuit-breaker was employed.

When the left-hand pole of the electro-magnet was made north the arrangement was called (1), and when the other pole was made north the arrangement was called (2). It will thus be seen that the current went round the magnet in the same direction as the molecular currents of arrangement (2).

Experiments were made at intervals of two minutes; and on each occasion the current was allowed to pass through the bridge for ten seconds, the measurement being taken by the first swing of the galvanometer, which lasted for about eight seconds. Three cells of Grove's battery were used for producing this current, but on the other hand six similar cells were employed for magnetising the electro-magnet. The distance of the magnet was too great to affect the galvanometer-needle so as to alter its sensibility, the average deflection causing a difference in the zero of about four divisions of the scale.

2. In the first experiments made the key was not taken out before the magnetism was put on or off, in consequence of which the induction-current due to the wire coiled round the magnet affected the galvanometer on these occasions; but after December 12th the key was taken out, so that no induction-current passed.

The table at top of next column is a specimen of the observations made.

Time of Putting on Current.	December 17, 1873. Whole Deflection observed (increasing deflection denotes increasing resistance in A, B, C, D).	Condition of Magnet.
11h. 11m.	312	off
13	317	off
15	311	off
17	345	(1)
19	328	off
21	306	(1)
23	303	off
25	293	(1)
27	300	off
29	290	(1)
31	307	off
33	283	(1)
35	292	off
37	288	(1)
39	302	off
41	292	(1)
43	309	off

It will be seen from this experiment that the *first effect* of putting on the magnetism was a marked increase of resistance; but with this exception the resistance, when the magnetism was on, was less than the mean of the two resistances on both sides of it, representing the magnetism off.

3. The arrangement remained untouched, as far as we know, from December 15th, when it was finally made, until December 19th, when the experiments were interrupted during the Christmas holidays; and in all cases the *first effect* of putting on the magnetism was a marked increase of resistance. For instance, we have—

Date.	First Off.	First Effect.	Second Off.
Dec. 16 ...	0	+36 on (2)	+ 3
„ 17 ...	0	+34 on (1)	+17
„ 18 ...	0	+54 on (1)	+24
„ 19 ...	0	+33 on (1)	−18

It was soon seen that this *first effect* had some reference to the time elapsing since the last experiments were made. For instance, in the above table we see for December 18th a marked increase of resistance when the magnet was first put on; but on the afternoon of that day the experiments were repeated, and there was no apparent increase of resistance in this *first effect*. Next, with regard to the *average effect* on Dec. 16th, 17th, and 18th, this *average effect* of magnetism was a decrease of resistance; but on Dec. 19th there was an apparent increase of resistance when the magnetism was on. We cannot say that nothing had been done to the arrangement between the 18th and 19th of December that might account for this change, but whatever was done must have escaped our recollection. Undoubtedly a good many experiments were made during the time between the 15th and 19th of December, and the direction of the magnetism was frequently changed. This curious anomaly occurring unexpectedly induced us to limit our future experiments to a definite set each day.

4. The experiments were resumed on January 7th, the arrangement having remained untouched during the holidays. From this date until January 10th inclusive the key was taken out before beginning experiments in the morning; there was no peculiar *first effect;* while, on the other hand, an *average effect*, denoting a decrease of resistance, came out very prominently. On January 12th and 13th the key was only taken out before magnetising, and on these occasions the *first effect* denoting increased resistance was sufficiently marked.

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* A paper read before the Royal Society May 7, 1874.

Our method of procedure was varied in the above manner up to January 27th, and it was invariably found that whenever the key was taken out before commencing experiments there was no *first effect*, but when it was kept in until before magnetising this *first effect* was sufficiently marked. These experiments concur in proving that the *first effect* has some reference to the previous treatment of the wire, but they do not prove that it is at the same time connected with the putting on of the magnetism. To determine this point we made a set of experiments on January 22nd, 26th, and 27th. When the current had become constant the key was taken out, but the magnetism was not put on; and on these occasions there was no *first effect* of the current upon itself in the direction of increased resistance, but rather in the opposite direction. It thus appears that the *first effect* which increases the resistance has not only reference to the previous treatment of the wire, but depends also upon the magnetism being put on.

This result is confirmed by experiments made previously to December 12th, in which the key was not taken out at all. For instance, we have on December 9th—

First Off.	First Effect.	Second Off.
0	+54	+45

We have hitherto only spoken of the *first effect* obtained after January 7th; we now come to the *average effect*. From January 7th to January 27th inclusive the magnetism was always put on in the direction (1), and the *average effect* invariably denoted a decrease of resistance when the magnetism was on.

5. On January 28th the magnetism was reversed; the effect during this day was very irregular. On January 29th, 30th, 31st, February 2nd, the key was left in until before magnetisation. The *first effect* was now extremely large, but it was suspected that during these experiments the contact of the key was not very good.

On January 29th the *average effect* denoted a decrease of resistance; but on January 30th, 31st, February 2nd, 4th, 6th, the *average effect* denoted an increase of resistance.

6. From February 6th until February 11th the wires were left broken; on February 11th there was a very slight *first effect* in the direction of increased resistance, and a slight *average effect* in the direction of decreased resistance. On February 12th a mercury interruptor was used instead of a metal key, both the wires being broken by it, and its use was continued until February 18th. The interruptor was left in over night, and the current was only broken before magnetisation, but no *first effect* was observed.

From February 19th to February 26th one wire only was broken by the fluid interruptor; nevertheless there was no *first effect*.

On February 12th, when the fluid interruptor was first employed, there was a very small *average effect* in the direction of increased resistance; but in all the experiments afterwards this *average effect* was in the direction of decreased resistance. The magnetism had been in the direction (2) from Jan. 28th, but during the experiment of Feb. 25th it was reversed, and retained in this condition through the experiment of Feb. 26th without appearing to affect the results.

7. From these experiments we may perhaps conclude as follows:—

In the *first place* there is a *first effect* in the direction of increased resistance which appears to have reference to three things, namely, the previous state of the wire, the solidity of the circuit, and its magnetisation.

In the *second place*, we have an *average effect*, of which the normal state appears to denote a decreased resistance while the magnetism is on, without reference to the direction of the magnetism.

In the *third place*, when in a solid circuit the direction of the magnetism has been recently changed, there appears to be a temporary reversal of the average effect, which appears at first as an increase of resistance. Besides the evidence herein detailed, we have other evidence in favour of the third conclusion; for in some preliminary experiments, in which we frequently reversed the poles, we found an increase of resistance when the magnetism was on. We have given in a table appended to this paper a synopsis of our various experiments.

8. We are led to conclude, from other experiments besides these, that the effect of the magnetism is not merely confined to the part of the copper wire wound round the poles, but is propagated all along the wire. On December 2nd, for instance, the current was passed through the wire, the galvanometer being joined as a secondary circuit. The main current was therefore measured.

The deflections were as follows:—

297	off	300	off
300	(1)	302	(1)
297	off	301	off
300	(1)		

This shows an average strengthening of the current equal to about 1-200th part of the whole. Were this strengthening due to merely the change of resistance of that part of the wire wound round the poles, the effect, as measured by the much more delicate arrangement of Wheatstone's bridge, would be much larger than was actually observed.

9. Allusion was made in Article 7 to some preliminary experiments in which increased resistance was observed when the magnetism was put on (1) and (2) alternately. Similar experiments were made, giving the same result with a piece of coke and graphite which were placed between the poles of the magnet.

10. We have also some evidence that a copper wire, one end of which is wound round the pole of the magnet, changes its position in the electromotive series. Two copper wires were dipped into dilute nitric acid, and connected with the galvanometer. A weak current passed through the galvanometer owing to a slight difference in the copper wires, one of which was also connected with the copper wire wound round the magnet. When the magnet was on, the current as a rule changed in intensity; but the effect was small, and the difficulty of having two copper wires—which, when joined together and dipped into nitric acid, give a current sufficiently weak and constant, prevented us from getting any decided results.

11. In conclusion, we have to state that we regard these results which we have ventured to bring before the Royal Society as preliminary, the correctness of which will, we trust, be confirmed by the further experiments which it is our intention to make.

Date.	Nature of Experiment.	Value of First Effect.	Number of Observations.	Mean Effect, excl. of First Effect (—denotes Decrease of Resistance).
1873.		Off. On. Off.		
Dec. 17.	Metal key left in over night taken out before magnetism was put on (1)	0+34+17	15	−14
„ 18.	Metal key left in over night taken out before magnetism was put on (1)	0+54+24	30	− 9
„ 19.	Metal key left in over night taken out before magnetism was put on (1)	0+33−18	15	+21
1874.				
Jan. 7.	The key was taken out before beginning the experiments in the morning	No first effect.	15	−17
„ 8.	The key was taken out before beginning the experiments in the morning	Ditto.	15	−19
„ 9.	The key was taken out before beginning the experiments in the morning	Ditto.	15	−13
„ 10.	The key was taken out before beginning the experiments in the morning	Ditto.	15	−20
„ 12.	The key was not taken out until before magnetising	0+47+18	15	−18
„ 13.	The key was taken out (same as Jan. 7)	No first effect.	Irregular action.	
„ 14.	The key was not taken out (same as Jan. 12)	0+3−6	15	−19
„ 15.	Ditto	0+17+11	15	− 2
„ 16.	The key was taken out (same as Jan. 7)	No first effect.	15	−67
„ 17.	The key was taken out (same as Jan. 12)	0+28+119	15	−22
„ 20.	The connexions had been broken since Jan. 17	No first effect.	15	−44
„ 21.	The key was not taken out (same as Jan. 7)	0+7+1	15	− 9
„ 22.	When the current was constant the key was taken out, but the magnet was not put on before the current had again become constant	No first effect.	15	−13
„ 24.	The key had been left out since Jan. 22	Ditto.	15	−11
„ 26.	Same as Jan. 22	Ditto.	15	−33
„ 27.	Ditto	Ditto.	15	−23
„ 28.	The magnet was put on (2) from this day until Feb. 25	—	—	—
„ 29.	The magnet was put on (2), key left in (same as Jan. 12)	0+102+47	15	−23
„ 30.	The magnet was put on (2), key left in (same as Jan. 12)	0+219	15	+25
„ 31.	The magnet was put on (2), key left in (same as Jan. 12)	0+137+161	15	+16
Feb. 2.	The magnet was put on (2), key left in (same as Jan. 12)	0+47+84	15	+11
„ 3.	—	—	—	—
„ 4.	The key was taken out, and put in after several offs, same as Jan. 22	No first effect.	15	+31
„ 5.	—	—	—	—
„ 6.	The key was taken out (same as Jan. 22)	No first effect.	15	+ 3
„ 11.	—	0+7+3	15	− 3
„ 12.	A mercury interruptor was used instead of metal key	No first effect.	31	+ 3
„ 13.	The mercurial interruptor was kept in over night	Ditto.	15	−11
„ 14.	The mercury interruptor was kept in over night	Ditto.	15	−36
„ 16.	New mercurial contact breaker from Elliott Brothers used	Ditto.	15	−18
„ 17.	Ditto key left in (same as Jan. 12)	Ditto.	15	− 5
„ 18.	Ditto ditto	Ditto.	15	− 7
„ 19.	One wire only was broken	0+11+16	15	− 2
„ 20.	One wire only was broken, key left in (same as Jan. 12)	No first effect.	15	−13
„ 22.	One wire only was broken, key left in (same as Jan. 12)	Ditto.	17	−12
„ 24.	One wire only was broken, key left in (same as Jan. 12)	Ditto.	17	− 8
„ 25.	One wire only was broken, magnet on (1)	Ditto.	15	− 4

REMARKS.

Dec. 18, 1873. For a second series of 15 on the day no first effect was found.

Jan. 15, 1874. There was a sudden change of the current during the experiments, to which the unusually small effect is most likely due.

Jan. 16. There was a sudden change of the current during the experiments, to which the unusually large effect is most likely due.

Jan. 17. There was an irregularity at the beginning of the experiment.

Jan. 20. Action somewhat irregular.

Jan. 22. There seemed to be a first effect of the current on itself in the opposite direction, 0−14−9.

Jan. 26. There seemed to be again a first effect in opposite direction, 0−47−57.

Jan. 27. There seemed to be again a first effect in opposite direction, 0−17−17.

Jan. 28. The action was very irregular.

Jan. 29. It is suspected that during the experiments from Jan. 29 to Feb. 12 the contact at the key was not very good.

Feb. 3. The action was very irregular.

Feb. 4. There seemed to be two first effects of the current upon itself in the direction of increased resistance.

Feb. 5. The action was very irregular.

Feb. 6. There seemed to be a first effect of decreased resistance of current upon itself.

Feb. 11. The wires had been broken since Feb. 6th.

Feb. 12. One of the wires had got between the pole and the core of the magnet.

Feb. 24. After the first on (2) the magnet was always put on (1).

A METHOD OF RECORDING MESSAGES SENT BY THE MIRROR OR BELL SYSTEM AT THE SENDING STATION.

By J. EDWARD MAYHEW.

It has seemed to me obvious that for long lines of cable, on which it has as yet been impossible, or uncertain, to use the Thomson's Recorder with ease and accuracy, the next best method would be to use a recorder at the transmitting end.

I have also judged, from observation, that a system by which the behaviour of the clerks at both ends could be brought accurately under the eye of the superintendent of the station, would effectually stop the frequent unnecessary discussions which are frequently the cause of much delay in the transmission of messages, which are either imperfectly sent or received by the operators at either end of the line.

Fig. 1.

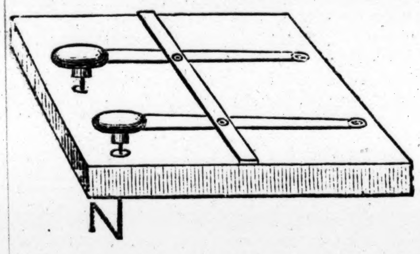


Fig. 2.

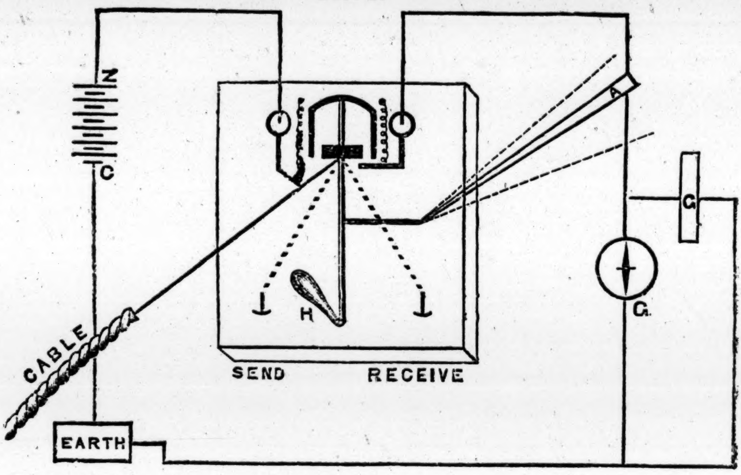


Fig. 3.

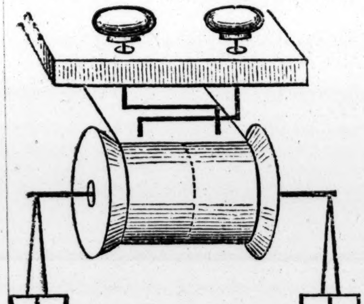
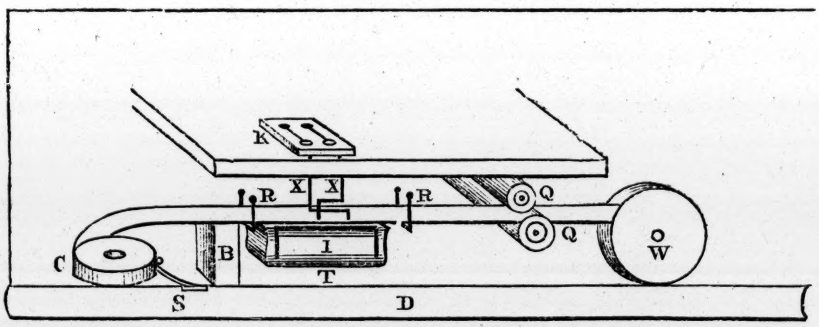


Fig. 4.



The effect of a check record, also, being made, even in cases where a recorder is used at the receiving end, would also tend to promote a feeling of absolute satisfaction in all cases of dispute; also of producing for the defaulter absolute evidence of the error having occurred.

The system which is herewith described seems to me to be capable of meeting and accomplishing all these desirable results.

Fig. 1 is an ordinary mirror transmitting key, the only difference being that there are two holes in the centre of the bottom contacts (which are to be made of rings instead of nuts of platinum), through which a small rod, attached to the vulcanite finger-pieces of the key, can with sufficient ease play up and down: the rod can be made of steel, or brass, tipped with vulcanite.

Fig. 4 shows this key placed on the sending table, on which, of course, the switch (Fig. 2) and the usual instruments, &c., would all be arranged; underneath this, in a drawer, or on a slab, or otherwise, would be placed the rest of the apparatus. C is a coil of paper, such as is used for the Morse instrument, only a little wider. S is a spring, so fixed as to prevent the coil C from revolving too easily, and to keep the proper strain on the paper. B is a block, or rest, over which it is to move to the two rests R R, which are intended to keep the paper in its proper place over the trough T. In the trough T is to be placed a sufficient quantity of ink, or acid, or anything which will rapidly dry, so as to keep a piece of spongeopyline (or any substance which will absorb the ink over its entire surface and at the same time not become too moist) constantly moist. Over the top of the trough, and close down on the sponge, will be a small sheet of tin, or glass, with two holes of the proper size to admit of the paper being pressed through (by means of the two rods attached to the finger-pieces of the key) to the damp sponge in the trough, and so marking it on either side with dots. The two fluted rollers, Q Q, are to be made to revolve by means of spring machinery, at a sufficient speed to draw the paper steadily along, and the wheel W—also made to revolve as necessary—is to receive it after receiving the impression, and to be removed when full, cleared, and replaced. I should propose that this apparatus should be arranged so as to last an entire day without interference, so that the clerks on duty need not touch it, but that it should be in the entire charge, under lock and key, of the clerk in charge or some other competent person.

Fig. 2 is a switch of the ordinary kind, so placed under a glass case (which is to be fastened down permanently) as to admit of the handle H being moved from left to right at will, the handle and the arm A only protruding from the case. A is an arm which is to be so placed as to set in motion or stop the apparatus, setting it in motion when the switch is placed to the left—to send, and stopping it when it is placed to the right—to receive; thus it will not be possible for any conversation to go on through the cable that is not recorded on the paper.

Fig 3. shows the underneath arrangement of the rods. It is proposed to reverse them, as shown, so that (the paper being marked underneath) when it is turned over for reading the dots and dashes shall appear on the right sides; but should this be found to be unadvisable, and in any way an impediment to the satisfactory working of the thing, of course straight rods could be used, and the reader of the slip would simply have to receive his signals to read with ease.

I am aware that this is a very faulty description of what I intend to convey, and am also aware that there may be many improvements made in what I have suggested; but these would be far better understood by one better acquainted with mechanism than I am, and to such an one I should look to perfect my idea, but I feel confident that the objects which I set forth in the first part of this paper can all be completely carried out by these means.

4, Haddington Terrace, Greenwich,
March 25, 1874.

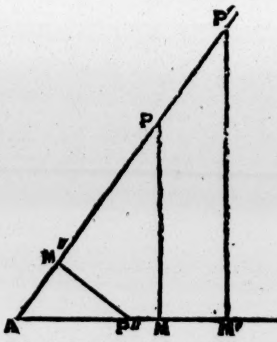
MATHEMATICS
FOR
NATURAL SCIENCE STUDENTS.

By T. C. SIMMONS, B.A.

(Continued from p. 168.)

TRIGONOMETRY (*Continued*).

Fig. 26.



LET us now take an angle A, and from a point in either of the lines containing it draw a perpendicular on the other line: we thus get a right-angled triangle. The ratio $\frac{\text{perpendicular}}{\text{hypothenuse}}$ will be constant wherever the point is taken. For if PM, $P'M'$ be two perpendiculars from points in the same line, then APM, $AP'M'$ are equiangular triangles (see last article, Fig. 12), or, as they are more usually called, *similar* triangles. Hence—

$$\frac{PM}{AP} = \frac{P'M'}{AP'},$$

as shown in the last article (Fig. 20). If, however, the perpendicular be drawn from a point P' in the other line, then since the three angles of the triangle APM are together equal to the three angles of $AP''M''$ (each sum being equal to two right angles), and that the angle A is the same in both triangles, and the right angle at M is equal to that at M'', it follows that the remaining angle at P is equal to the remaining one at P', or that the triangles are similar.[*] Hence, as before,—

$$\frac{P'M'}{AP''} = \frac{PM}{AP}.$$

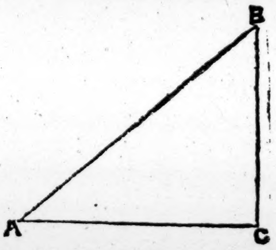
This ratio $\frac{\text{perpendicular}}{\text{hypothenuse}}$ is called the *sine* of the angle A, and is expressed thus:—Sin A. Similarly it may be shown that the ratio $\frac{\text{adjacent side}}{\text{hypothenuse}}$ is always the same, and is equal to the ratio $\frac{AM}{AP}$. This ratio is called the *cosine* of the angle A, and is expressed thus:—Cos A. The ratio $\frac{\text{perpendicular}}{\text{adjacent side}}$, as $\frac{PM}{AM}$, is similarly constant, and is called the *tangent* of A, or tan A.

Suppose now we have a right-angled triangle, BAC. Then $\sin A = \frac{BC}{AB}$.

$$\text{But } \cos B = \frac{BC}{AB} \text{ also.}$$

Hence $\sin A = \cos B$.
So $\sin B = \cos A$.

Fig. 27.



Now C being a right angle, it follows that A and B together make up a right angle. That angle which, when added to a given angle, makes up a right angle is called the *complement* of that given angle. Thus B is the complement of A, and A the complement of B, and we get this result:—The sine of an angle is equal to the cosine of its complement, and the cosine of an angle is equal to the sine of its complement.

$$\text{Again, } \tan A = \frac{BC}{AC} = \frac{\frac{BC}{AB}}{\frac{AC}{AB}} = \frac{\sin A}{\cos A}.$$

$$\text{So } \tan B = \frac{\sin B}{\cos B}.$$

But there are three other ratios which have not yet been considered; these are the inverse of the former. The inverse of the sine of A or $\frac{AB}{BC}$ is called the cosecant of A, and is expressed thus:—

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[*] Thus it is seen that any two triangles which have two angles of the one equal to two angles of the other, each to each, are similar.

Cosec A. The inverse of the cosine of A, or $\frac{AB}{AC}$, is called the *secant* of A, and is expressed thus:—Sec A. The inverse of the tangent, or $\frac{AC}{BC}$, is called the *cotangent* of A, or cot A.

These six ratios are called the *trigonometrical ratios of an angle.* The student should, for exercise, draw right-angled triangles in all kinds of positions, and should get accustomed to express readily the different ratios of either of the angles of any one of these in terms of the sides of the figure.

To show that $(\sin A)^2 + (\cos A)^2 = 1$:—

Let B A C be a right-angled triangle (Fig. 27); then sq. on B C + sq. on A C = sq. on A B. Now if the length of B C were 5 inches, the area of the square on B C would be 5^2 square inches; and so if B C were of any other length, the area of the square would be found by multiplying that length by itself.

Thus the square on B C may be represented by BC^2. So the squares on A C, A B, may be represented by AC^2, AB^2, and $BC^2+AC^2=AB^2$.

Divide by AB^2, then—

$$\left(\frac{BC}{AB}\right)^2+\left(\frac{AC}{AB}\right)^2=1,$$

$$(\sin A)^2+(\cos A)^2=1.$$

This is usually expressed—

$$\sin^2 A+\cos^2 A=1 \quad . \quad . \quad . \quad (1)$$

$\sin A$ being used to denote $(\sin A)^2$, $\sin A$ to denote $(\sin A)^3$, and so on.

If we divide each side of the equation

$$AB^2=BC^2+AC^2$$

by AC^2, we get—

$$\left(\frac{AB}{AC}\right)^2 = \left(\frac{BC}{AC}\right)^2 + 1,$$

$$\text{or } (\sec A)^2 = (\tan A)^2 + 1,$$

or, with the usual notation,—

$$\sec^2 A = 1 + \tan^2 A \quad . \quad . \quad . \quad (2)$$

If we divide the same equation by BC^2, we get—

$$\left(\frac{AB}{BC}\right)^2 = 1 + \left(\frac{AC}{BC}\right)^2$$

$$\text{or } \operatorname{cosec}^2 A = 1 + \cot^2 A \quad . \quad . \quad . \quad (3)$$

These three equations, which should be carefully committed to memory, enable us to express any one of the ratios in terms of any one of the others.

We get from (1)—

$$\sin^2 A = 1 - \cos^2 A,$$

$$\text{or } \sin A = \sqrt{(1-\cos^2 A)} \quad . \quad . \quad (4)$$

So—

$$\cos A = \sqrt{(1-\sin^2 A)} \quad . \quad . \quad (5)$$

From (2)—

$$\sec A = \sqrt{(1+\tan^2 A)} \quad . \quad . \quad (6)$$

$$\tan A = \sqrt{(\sec^2 A - 1)} \quad . \quad . \quad (7)$$

From (3)—

$$\operatorname{cosec} A = \sqrt{(1+\cot^2 A)} \quad . \quad . \quad (8)$$

$$\cot A = \sqrt{(\operatorname{cosec}^2 A - 1)} \quad . \quad (9)$$

Now suppose, for instance, we wish to express sec A in terms of sin A:—

We have $\sec A = \sqrt{(1+\tan^2 A)}$

$$= \sqrt{\left(1+\frac{\sin^2 A}{\cos^2 A}\right)}$$

$$=\sqrt{\frac{\cos^2 A+\sin^2 A}{\cos^2 A}}$$

$$=\sqrt{\frac{1}{\cos^2 A}}$$

$$=\sqrt{\frac{1}{1-\sin^2 A}}$$

$$=\frac{1}{\sqrt{(1-\sin^2 A)}},$$

Or, more simply,—

$$\sec A = \frac{1}{\cos A} = \frac{1}{\sqrt{(1-\sin^2 A)}}.$$

So, if we require the sine in terms of the secant, we have—

$$\sin A = \sqrt{(1-\cos^2 A)} = \sqrt{\left(1-\frac{1}{\sec^2 A}\right)}$$

$$=\sqrt{\frac{\sec^2 A - 1}{\sec^2 A}}$$

$$=\frac{\sqrt{(\sec^2 A - 1)}}{\sec A}$$

Or thus:—

$$\tan A = \frac{\sin A}{\cos A}$$

$$\therefore \sin A = \tan A \cos A$$

$$=\frac{\tan A}{\sec A}=\frac{\sqrt{\sec^2 A - 1}}{\sec A}.$$

Again, if we require the sine in terms of the tangent,—

$$\sin A = \sqrt{(1-\cos^2 A)}$$

$$=\sqrt{\left(1-\frac{1}{\sec^2 A}\right)}$$

$$=\sqrt{\left(1-\frac{1}{1+\tan^2 A}\right)}$$

$$=\sqrt{\frac{1+\tan^2 A - 1}{1+\tan^2 A}}$$

$$=\frac{\tan A}{\sqrt{(1+\tan^2 A}},$$

Or, more briefly,—

$$\text{Since } \tan A = \frac{\sin A}{\cos A}$$

$$\text{We have } \sin A = \tan A \cos A$$

$$=\frac{\tan A}{\sec A}$$

$$=\frac{\tan A}{\sqrt{(1+\tan^2 A}}.$$

So any other of the ratios may be expressed in terms of any given one.

It may be useful to collect all the results just proved, for the sake of reference:—

(*a*) The sine of an angle is equal to the cosine of its complement, and *vice versa*.

(*b*) In the same way the tangent of an angle is equal to the cotangent of its complement, and *vice versa*.

(*c*) Also the cosecant is equal to the secant of the complement, and *vice versa*.

(*d*) $\tan A=\dfrac{\sin A}{\cos A}$, $\sin A = \tan A \cos A$, $\cos A = \dfrac{\sin A}{\tan A}$.

(*e*) $\sin A = \frac{1}{\operatorname{cosec} A}, \quad \operatorname{cosec} A = \frac{1}{\sin A}.$

(*f*) $\cos A = \frac{1}{\sec A}, \quad \sec A = \frac{1}{\cos A}.$

(*g*) $\tan A = \frac{1}{\cot A}, \quad \cot A = \frac{1}{\tan A}.$

(*h*) $\sin {}^2A + \cos {}^2A = 1$
$\sin A = \sqrt{(1 - \cos {}^2A)}$
$\cos A = \sqrt{(1 - \sin {}^2A)}.$

(*i*) $\sec {}^2A = 1 + \tan {}^2A$
$\sec A = \sqrt{(1 + \tan {}^2A)}$
$\tan A = \sqrt{(\sec {}^2A - 1)}.$

(*j*) $\operatorname{cosec} {}^2A = 1 + \cot {}^2A$
$\operatorname{cosec} A = \sqrt{(1 + \cot {}^2A)}$
$\cot A = \sqrt{(\operatorname{cosec} {}^2A - 1)}.$

The following are exercises which the reader should work out for himself:—

Prove that—

$$\tan A + \cot A = \sec A \operatorname{cosec} A.$$

Proceed thus:—

$$\tan A + \cot A = \tan A + \frac{1}{\tan A}.$$

$$= \frac{\tan {}^2A + 1}{\tan A} = \frac{\sec {}^2A}{\tan A}$$

$$= \frac{\frac{1}{\cos {}^2A}}{\frac{\sin A}{\cos A}}$$

which, if we multiply both numerator and denominator by $\cos {}^2A$, becomes—

$$\frac{1}{\sin A \cos A} = \frac{1}{\sin A} \cdot \frac{1}{\cos A}$$

$$= \operatorname{cosec} A \sec A.$$

Given $\tan A = \frac{3}{4}$, find all the other trigonometrical ratios of A.

We have $\sin A = \frac{\tan A}{\sqrt{(1 + \tan {}^2A)}}.$

Hence if $\tan A = \frac{3}{4}$,—

$$\sin A = \frac{\frac{3}{4}}{\sqrt{(1 + \frac{9}{16})}}$$

$$= \frac{\frac{3}{4}}{\sqrt{\frac{25}{16}}} = \frac{\frac{3}{4}}{\frac{5}{4}}$$

$$= \frac{3}{5}.$$

$$\cos A = \frac{\sin A}{\tan A} = \frac{\frac{3}{5}}{\frac{3}{4}}$$

$$= \frac{4}{5}.$$

$$\cot A = \frac{1}{\tan A} = \frac{4}{3}.$$

$$\operatorname{cosec} A = \frac{1}{\sin A} = \frac{5}{3}.$$

$$\sec A = \frac{1}{\cos A} = \frac{5}{4}.$$

Similarly, if the value of the sine, or cosine, be given, we can find the values of all the other ratios; or if the value of the cotangent, secant, or cosecant, be given, which amounts to the same thing, these being the inverse of the other ratios.

WIRES AND THEIR PROPERTIES.

By J. T. SPRAGUE.

THOSE who employ and purchase wires are frequently subjected to much inconvenience owing to the great uncertainty which exists as to the different gauges; for though wire is usually bought by Birmingham wire-gauge, this is really a name without an object belonging to it, for no one knows what the Birmingham wire-gauge is, and different dealers will differ two or three sizes, while, in the finer wires, it is a mere chance what will be obtained for any gauge asked for. This confusion can be remedied only by abandoning the gauges altogether, and falling back upon definite principles, of which there are two available:—(1). The measured diameter of wires; (2). The weight in a given length; which latter is already employed on the large scale, as in contracts for telegraphic purposes.

Another difficulty arises from the impossibility of obtaining concordant results from the various tables and formulæ given in the published books. This is no doubt due to the data having been obtained by measuring and weighing actual wires, a process much more liable to error than calculations based on fixed principles.

In writing of or in purchasing wire, the diameter is the usual basis of calculation, but most of the properties of wire are really related to the square of the diameter, that is, the sectional area, and there are two ways of regarding this latter. The most usual mode is to calculate the relation of it to 1 square inch, which is a very effectual way of hiding as much as possible the knowledge required. But if, instead of regarding each wire as an individual thing, we fix upon a definite wire as the unit, and regard all wires as consisting of a number of these unit wires, all the calculations become simple, and the reasons of the variations of weight, resistance, &c., are self-evident. Of course, the metric measures would furnish the best system, but as this is practically out of the question, the best plan available is to take for the unit of measure the one-thousandth of an inch, already frequently so used, and called a "mil." Since wires are round, and the areas of circles increase as the squares of the diameters, we should regard the "mil" as a circular wire. Then, by squaring the diameter in "mils" of any wire, we obtain direct its area in circular mils,—that is to say, the number of unit wires to which it is equivalent. To make the unit complete, its length must be defined, and the foot is the most convenient measure.

In electricity, we require to include in our unit electric resistance as well as the weight, &c., and this would easily be done; but it is still more convenient and generally useful to make weight, rather than diameter, the basis of the unit, and the most generally useful unit would appear to be a wire, 1 foot long, weighing 1 grain. By ascertaining the relation of this for each metal to the general circular *mil* foot, every necessary calculation can be readily effected, as will be seen by the following calculations.

A wire is simply a cylinder occupying a certain measurement of space; the weight of the cylinder will depend upon the specific gravity of the material which fills the space.

A cubic inch of water weighs 252·456 grs., and this multiplied by 12 and by 0·7854 gives us the weight of a circular inch-foot of water; and that multiplied by the specific gravity of any metal gives the weight of a circular inch-foot of that metal, and thus the datum for all required calculations. This is readily worked out in logarithms, taking copper, specific gravity 8·9 as the basis, this being the average specific gravity of good copper wire:—

Cubic inch of water 252·456 ..	2·4021857	
12 in. per foot	1·0791812	
0·7854, ratio of circle to square	$\bar{1}$·8950909	
Circular inch-foot of water ..	3·3764578	= 2379·3
Specific gravity of copper, 8·9	0·9493900	
Circular inch-foot of copper ..	4·3258478	= 21176·1

This divided by 1000×1000=1,000,000, gives the weight in grains of a wire of a circular *mil* 1 foot long, as 0·0211761. The figures in column 2 of the table of constants below have been thus obtained.

By dividing 1,000,000, the circular *mils* in an inch, by the weight of the circular inch-foot, we obtain the sectional area in *mils* (or number of *mils* it occupies) of a wire weighing 1 grain per foot. This gives column 3 of the table of constants:—

1,000,000	6·0000000	
Inch-foot of copper, 21176·1	4·3258478	
Mils per grain-foot, G	2)1·6741522	= 47·220
Diameter of grain-foot	0·8370761	= 6·872

This gives us the grain-foot unit wire of copper, and, assuming as correct the resistance of one foot-grain wire given by Fleeming Jenkin and calculated from the experiments of Mathiessen, we obtain all that is necessary to complete the data, viz., the resistance of the unit foot-grain wire, which is calculated at 60 deg. and inserted in column 4 of the table.

Resistance of one foot-grain soft copper at 32 deg., 0·2064 ..	$\bar{1}$·3147097	
Correction for 28 deg., 1·0605	0·0255107	
Unit resistance at 60 deg., U ..	$\bar{1}$·3402204	=0·21889

This unit wire, 1 foot weighing 1 grain, and having, as pure soft copper, a resistance at 60 deg. Fahr. of 0·21889 ohm, will now furnish any information needed by simple processes of calculation.

CONSTANTS OF WIRES.

	I.	II. M.	III. G.		IV. U.	
	Specific gravity.	Grains per *mil*-foot.	Area in *mils* per grain-foot.		Resistance at 60 deg. Fahr. of foot-grain.	
			Mils.	Log.	Ohms.	Log.
*Copper	8·9	0·0211761	47·22	1·6741522	0·2189	$\bar{1}$·3402204
Iron	7·8	0·0185590	53·88	1·7314476	1·1634	0·0657173
*German Silver	8·7	0·0207003	48·31	1·6840229	2·6699	0·4264939
Brass	8·4	0·0199865	50·03	1·6992629	0·9938	$\bar{1}$·9972763

* As both copper and German silver vary in conductivity, the figures for resistance are only standards to be replaced or corrected by the known conductivity of any wire.

Let the following symbols represent the several elements:—

d, diameter in *mils*.
d^2, square of d = sectional area in circular *mils*.
w, weight in grains per foot.
l, length in feet.
M, grains per *mil* foot of the metal, column II. of table.
G, area in *mils* (d^2) of unit grain-foot, column III. of table.
U, resistance in ohms of unit wire, column IV. of table.
R, measured resistance at 60 deg.

I. *To ascertain the* DIAMETER, d, *of any wire*, weigh and measure carefully any convenient piece, and reduce to grains per foot. Multiply this by the constant G in column III. (47·22 for copper). This gives the sectional *area* in *mils*, d^2, and the square root of this is the diameter in *mils*, d.

$$d = \sqrt{w\,\mathrm{G}}.$$

ex. 4ft. weigh 3·15 grs.	0·4983106	
Divided by 4	0·6020600	
w, grains per foot	$\bar{1}$·8962506	= 0·788
G, constant for copper, 47·22 ..	1·6741522	
d^2, sectional area	2)1·5704028	= 37·10
d, diameter in *mils*	0·7852014	= 6·1

For other metals the proper constants should be used.

II. *The diameter being known, to ascertain the* WEIGHT *of any length, or the* LENGTH *of any weight*, multiply the square of the diameter by column II. of the table, the grains per *mil*-foot. This gives the weight in grains per foot, from which all required weights and lengths are ascertainable by common arithmetic.

$$w = d^2\,\mathrm{M}.$$

Or, dividing the square of the diameter by the area of the grain-foot, G, column III., will also give the grains per foot.

$$w = d^2 \div \mathrm{G}.$$

The square of the diameter, by using the following constants, will give the particular information, in each case, for copper wire.

		Log.
Feet per pound, divide by d^2	330560	5·5192502
Yards per pound, divide by d^2	110187	5·0421289
Grains per foot, multiply by d^2	0·0211761	$\bar{2}$·3258478
Pounds per 1000 feet, multiply by d^2	0·0030252	$\bar{3}$·4807498
Pounds per mile (English), multiply by d^2	0·015973	$\bar{2}$·2033837
Pounds per nautical mile, multiply by d^2	0·018414	$\bar{2}$·2651531

The same constants, used in the opposite manner, will give the area, and hence the diameter of a wire, of which any of these particulars are known.

III. *To ascertain the* RESISTANCE *of any wire at* 60 *deg.*, divide the unit resistance U, column IV., by the weight in grains per foot. This gives the resistance per foot, which multiply by length required.

$$\mathrm{R} = \mathrm{U} \times \frac{l}{w}$$

Or, multiply U by the length in feet, and divide the product by the area, multiplied by M, the grains per *mil*-foot.

$$\mathrm{R} = \frac{\mathrm{U}\,l}{d^2\,\mathrm{M}},\ \text{or}\ \frac{\mathrm{U}}{\mathrm{M}} \times \frac{l}{d^2}$$

This last formula gives another constant, the resistance of the *mil*-foot at 60 deg., which might, if preferred, serve as the principal unit instead of the grain-foot.

The foregoing formulæ are applicable to all the metals, using the proper constants; but the following constants, for special purposes, apply to copper only. They are, in fact, the resistances of a wire of one-thousandth inch diameter of the length named at 60 deg., and are to be divided by the sectional area in *mils*, d^2.

Ohms per foot at 60°	10·3365	Log.	1·0143726
Ohms per yard	31·0095	,,	1·4914939
Ohms per mile	54,577	,,	4·7370065
Ohms per nautical mile at 60°	62,918	,,	4·7987759
For Ohms per pound divide by d^4 or the square of the area $(d^2)^2$..	3,416,825	,,	6·5336228
For feet per Ohm multiply d^2 by..	0·0967447	,,	-2·9856274

IV. *To measure Conductivity.*—Measure the resistance of any convenient length, correcting for temperature to 60 deg. Divide by the length in feet, and multiply by the weight in grains per foot. This gives the resistance per grain foot, by which divide the unit 0·21889. The quotient is the conductivity.

$$C = U \div \frac{R\,w}{l}.$$

Example.—The 4 feet of wire, weighing 3·15 grains, used as the first example, gave a resistance, at 72 deg. of Ohms, 1·349

Resistance, 1·349	0·1300119
72 - 60 = 12°, correction, 1·0255	0·0109357
R, resistance at 60°, 1·315 = ...	0·1190762
w, grains per foot, 0·788	-1·8962506
	0·0153268
l, length 4 feet	0·6020600
Res. per grain-foot at 60°, 0·25898 = ..	-1·4132668
Unit grain-foot resistance, 0·21889	-1·3402204
Actual grain-foot resistance, 0·25898 ..	-1·4132668
Conductivity, 84·5 per cent = ...	-1·9269536

Or, measure and weigh any length of which the resistance is known, and multiply U by the length, and divide by weight per foot, which gives the equivalent resistance as pure copper, which divide by the actual resistance.

ON FORTH-CARRYING DISCHARGES OF ELECTRICITY.

KUNDT made the observation that when an electric discharge takes place, in free air, between a metallic plate strewn with lycopodium and a fine metallic point, there is left on the plate, after brushing away the superfluous dust, a well-defined circular dust spot. It was later shown that the size of the spot depended on the potential of the discharged electricity and the distance of point from plate. Dr. Röntgen has further studied the phenomenon (*Poggendorff's Annalen*, No. 1, 1874), and we propose to give some account of his results.

He first tried the effect of different kinds of gas. On a dust-strewn zinc plate was placed a receiver, into and from which, by suitable tubing, gas could be admitted or removed. A thin rod, with point near the plate, passed up through the glass, and was connected with the outer coating of a Leyden jar, the plate being connected with the (positively) charged inner coating. With air the dust-circle was (on an average) 72 m.m. diameter; with CO_2, 79 m.m.; with ordinary gas, 90 m.m.; with hydrogen, 93 m.m. The order of gases agrees with that found by Faraday for the striking distance.

The thickness of the lycopodium-layer introduces variations. The author got, under otherwise similar conditions, circles increasing from 75 m.m. to 90 m.m., with increasing thickness.

The size of the circle is greatly dependent on the size of the metallic plate. Dr. Röntgen puts the numerical results in form of a curve, and it appears that, with continuously-increasing abscissæ (size of plate), the ordinates, representing diameters of spots, approached a determinate, ultimate value, nearly reached with a very large plate. The curve with the equation $x = \frac{b\,y}{a - y}$ possesses the same property, when a and b represent finite constants: thus the value a would represent the size of a dust circle on an infinitely large plate. The author applies this, comparing calculation with observation, and the agreement is close. As examples of the numbers obtained:—With a plate 40 m.m. diameter the circle was 25 m.m.; with 131 m.m. diameter, 57 m.m.; with 285 m.m. diameter, 82 m.m. If the plate is connected with the earth, and the rod with the positive or negative coating of the jar, the variation of circle-size with plate is not so considerable: with small plates (40 m.m.) the lycopodium sticks over the whole surface.

The substitution of equal-sized plates of copper or lead has no marked influence on the size of the circle.

The next point considered was the effect of variation in distance of point from plate. In the author's experiments (in order to vary this distance) the vertical point could be pushed along a horizontal slide, and the plate had a slightly inclined position. He gives a number of the curves obtained. And first, they do not agree with Schneebeli's curves in being wavy. Then the diameter of circle increases with increase of distance of the point, up to a maximum value; from that point, with further increase of the distance, the circle becomes less, and ultimately *nil*. The position of the maximum depends (other conditions equal) on the sharpness of the point; the blunter this is, the sooner is the maximum reached. Further, the maximum is sooner reached (other conditions equal) the less the size of the plate. To eliminate, as far as possible, the variable influence of plate size, Dr. Röntgen experimented with a 1 metre plate. The curves he got give no indication of a turning-point. It appears that from a point which about corresponds to a distance of 10 m.m. the curve passes into a straight line; thereafter the increase of the circle's diameter is nearly proportional to the increase of distance of the point.

Next, as to the kind of electricity with which the point is charged. The curves show that the circles obtained with positive charge of the point are less than those with negative charge. Now the experiments of Faraday and others have proved that on passage of electricity, in a gas, between electrodes of unequal size, the striking distance (other things equal) is greater if the smaller electrode is negative than if it is positive; or, that the passage of electricity is easier where the small electrode is negative. Comparing this with the results just given, it appears that the dust circle (other things equal is greater the more the passage of electricity is facilitated.

As to the exact nature of the phenomenon, Dr. Röntgen supposes it to be this:—The half-conductors on the plate are electrified by the electric air particles coming from the point, and retain the electricity for a short time: they are, in consequence, strongly attracted by the unelectric or oppositely electrified plate, with which they closely unite. The sticking of the powder thus arises from the formation of a closer, more compact, layer. With illumination, from one side, the difference between the union of the two parts of a thin lycopodium layer can be easily observed, through difference of clearness. Hence may be understood how the dust figures are produced better on rough than on polished surfaces.

Dr. Röntgen endeavours to form a conception of what takes place in the discharge. The point is surrounded by a gas; the gas particles in contact with it receive its electricity, and are repelled. If an oppositely electrified body is near, it attracts them, and if no mechanical hindrance is present they come against this body, and share their charge with it. They are, however, electrified in turn by this body, and a return movement takes place to the point. Should these returning particles meet others coming from the point, a partial compensation takes place, and the united particles are anew attracted to the body. In the experiments above referred to, evidently, the motion is mainly, almost exclusively, from point to plate. The density of electricity at the point predominates over that of the plate; the force sending the particles in one direction is much greater than that sending them in the other.

The phenomena of the electric wind and the electric fly-wheel are in accordance with the foregoing representation, and the author made a further experiment which supported it:—Putting over the metallic point a bell-jar, open below and fed with ordinary gas, and with its edge at some distance from the plate, he observed quite distinctly, on electrification of the point, a conical-shaped quantity of the gas, of considerable breadth, projecting out of the bell, and coming against the plate.

The sharply-defined nature of the dust circle is a curious point. Why should the electric air-particles keep within such a definite limit?

With the varying distribution of electricity in the conical metallic point, the charged particles are driven forth with varying velocities in all possible directions. Considering the introduced attraction of the plate, we can at the most explain how, through a horizontal plane under the point, more electric particles pass than before; but not how there is found a sharply definite space within which the particles move. But suppose, further, that a mechanical resistance is presented to the motion of an air-particle away from the point, and that this is first overcome with a determinate electric repulsion, —it then becomes intelligible how only at a particular part of the point, where the density of electricity acquires that particular repellent force, the rapid forth-carrying discharge occurs. This resistance Dr. Röntgen supposed presented by a condensed badly-conducting gas-layer at the surface of the conductor, which must be broken through by the gas-particles. Once beyond the layer, the particle follows the path in which the electric force impels it, and with considerable energy if the repulsion required for breaking through is comparatively great. Thus may be explained the good insulating power of gases for electricity of small density.

For a particle to escape, the resultants of the electric forces acting on it must be greater than the resistance. Now, in an electrified cone facing a metallic plate, these resultants increase as you come nearer to the point; hence follows, first, that the motion of particles under the point is greatest; second, that there is a quite determinate radius of the cone, where the air-particles are no longer driven forth, though neighbouring particles may be, and with great energy. This quite explains the formation of a sharply-defined space, within which the particles move. The position of this radius will vary with the size of the plate, rising higher the larger this is.

The supposition of a condensed gaseous layer on solid bodies is pretty generally held, and attention has repeatedly been called to its influence in electrical phenomena (by Thomson and others). Several things observed by the author confirmed the idea. Thus, with a point that had not been used for several hours, the first dust figure was the smallest; then they gradually increased to constant dimensions. If the point was used with a strong discharge, the dust figure got immediately after, with a weaker discharge, was larger than one later (with the less discharge). With rarefaction of the air the circles are increased, &c.

Referring to Prof. Guthrie's recent experiments, Dr. Röntgen finds in them confirmation of the hypothesis; and, to conclude, the case may thus be stated:—At ordinary temperature every solid body, in free air, is enveloped by a condensed insulating gas-layer; this hinders or retards the motion of a gas-particle from the immediate surface of the body outwards; hence (slow dissipation aside) a rapid forth-carrying discharge can only occur at those parts of the body where the electric forces can overcome this resistance. If this gas-layer is removed by elevation of temperature, the experiment shows that a sudden discharge through the surrounding air always occurs.

THE NEW ELECTRIC LIGHT.

On the evening of the 5th inst. some interesting experiments with MM. Ladygin and Kosloff's electric light were conducted at the engineering works of Messrs. Warner, 10, Diana Place, Euston Road. To obviate the difficulty of carbon being consumed when burnt in contact with oxygen, M. Ladygin placed sticks of carbon in a closed glass chamber filled with a gas not containing oxygen, but owing to the use of metallic connections the carbon was subject to fracture. The subject was then taken up by M. S. A. Kosloff, of St. Petersburg, and 6, Great Winchester St. Buildings, London, who has succeeded in overcoming the difficulties by using a special metal of which he forms the holders for the carbon rods, and these are placed in a closed glass chamber.

The lamps which were experimented with were nine in number, six of them having two carbon rods, either of which could be placed in connection with the current of electricity. The rods were all 18 millimetres in length, and one in each lamp was 2 millimetres in thickness, the others being 1¾ millimetres thick. The other three lamps contained each a carbon rod 70 millimetres in length, 2 millimetres thick, and also connected with the main current. The first experiment consisted in burning a carbon rod in contact with the atmosphere, the rod being consumed in a few minutes. The current was then turned on to the thicker rod in each of the six lamps, and a brilliant and steady light was produced, which improved as the current was increased in intensity. The reason for lighting the thicker rod first was that it might consume the oxygen in the lamp, by which the rod was reduced a quarter of a millimetre, and was thus brought down to the gauge of the second rod. The current was then directed through the second rod with equally satisfactory results in all the six lamps. The three lamps with the longer carbon rods were then lighted and successfully exhibited, changes being frequently made from the six to the three lamps and back again. The apparatus used for producing the current was Gramme's magneto-electric machine. With the machine running at about 200 revolutions per minute a moderate light was obtained, which was greatly improved at 300 revolutions, the *maximum* of intensity being obtained at 450 revolutions. The strength of the light depends upon three things—the power of the machine and the number of its revolutions, on the length and thickness of the carbon rods, and on the quality of the carbon. The experiments showed that with the same strength of current and the same number of revolutions, double the amount of light was obtained with the three long carbon rods as compared with the six short ones. The experiments demonstrated satisfactorily the fact that the electric current could be subdivided, and hence, if practice confirms experiment, which it is believed it will, there is a wide field open for the application of Kosloff's system. The form of lamp used by the inventor is experimental, and its variation does not affect the principle. He leaves it to mechanical science to devise a lamp which shall meet the varied requirements of lighthouses, mines, submarine works, railways, and other purposes, to which it was the general opinion of those present on Tuesday the principle is thoroughly applicable.

Electrical Science in English and Foreign Journals.

(In addition to our usual abstracts, there will be found under this heading the titles of papers on electrical science which have appeared in English and foreign journals from the commencement of the present century up to the date of the establishment of this journal).

Poggendorff's Annalen der Physik und Chemie.

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Isodynamic Lines for Magnetic Force. M. Hansteen. Pp. 49, 229.

Determination of Declination of the Magnetic Needle by a Mirror. M. Riese. P. 67.

The Observations of Magnetic Intensity, with Reference to Temperature, and the Influence of the Northern Light on the Magnetic Needle. M. Hansteen. P. 161.

Relation Between Magnetic Force and Number of Pairs of Plates of a Voltaic Battery, and its Causes. M. Marianini. P. 165.

A New Class of Electro-Chemical Phenomena. M. Nobili. P. 183.

Contact Electricity Produced Through Difference of Temperature, and its Application to the Determination of High Temperatures. M. Becquerel. P. 345.

Magnetisation. M. Savary. P. 443.

The Action of Electric Discharges Going through Straight Conducting Wires. M. Savary. P. 449.

Magnetic Action of Solar Rays. Mr. Christie. P. 505.

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Attraction of the Magnetic Needle by Glowing Iron Observed by Messrs. Barlow and Bonnycastle, M. Seebeck. P. 47.

Magnetisation (Concluded). M. Savary. P. 73.

Magnetic Polarisation of Various Metals, Alloys, and Oxides, between the Poles of Strong Magnets. M. Seebeck. P. 203.

Magnetism of Bismuth and Antimony. M. Becquerel. P. 292.

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A Peculiar Property of Metallic Conductors of Electricity. M. Aug. de la Rive. P. 425.

Researches on Variations in the Mean Duration of Horizontal Vibration of the Magnetic Needle at Kasan, and on Various Other Points of Terrestrial Magnetism. M. Kupffer. P. 545.

Observations on the Daily Variation and Time of Oscillation of the Horizontal Magnetic Needle, Observed on the Third Voyage of Captain Parry. P. 570.

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The Electricity of Elastic Fluids, and one of the Causes of Atmospheric Electricity. M. Pouillet. P. 417.

The Electricity Obtained from Metallic Wires when Inserted in a Flame. M. Becquerel. P. 437.

The Electricity Developed in Chemical Actions, and on the Source of Electricity in the Atmosphere. M. Pouillet. P. 442.

On Chemical Decompositions Wrought by Electric Forces of Very Weak Tension. M. Bequerel. P. 457.

Vol. XII. (1828).

Researches on the Distribution of Free Magnetism in Magnetic Bars. M. Kupffer. P. 121.

Some Electric Phenomena Obtained through Pressure and Cleavage of Crystals. M. Becquerel. P. 147.

The Conductive Power of Various Metals for Electricity. Mr. Harris. P. 279.

Further Data as to the Influence of Auroras on the Magnetic Needle. M. Arago. P. 320.

Disturbance of the Magnetic Needle During an Earthquake in the Rhine Region in 1828. P. 328.

Addition to Memoir on the Magnetism Excitable in all Metals through Division. M. Seebeck. P. 352.

The Attraction Between Homogeneous and Heterogeneous Electrified Conductors. M. Strehlke. P. 478.

Some Observations on the Law of Electrical Repulsion. M. Egen. P. 595.

The Magnetic Actions Produced in all Bodies Under the Influence of Strong Magnetic Bars. M. Becquerel. P. 622.

Vol. XIII. (1828).

Theory of Electricity. M. Bigeon. P. 614.

The Electricity Excited by Friction of Two Metals. M. Becquerel. P. 619.

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Influence of Magnetism on Chemical Action. P. 631.

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Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxviii., No. 14.

Action of the Electric Fluid on Gases.—Third note of M. Neyreneuf.—The experiments already described in two preceding notes[*] were made with Holtz's machine, by which were produced at the same time the effects of attraction and repulsion of a flame by a negative and positive point. With a Ramsden machine and a Leyden jar the same effects were well marked. In this latter instance the repulsive effect of the flame begins to appear at a distance of 40 centimetres. With the induction spark one obtains literally no effect, as M. du Moncel has observed. One may, however, by connecting the point with the exterior positive pole, whilst the other pole is insulated, obtain a marked crushing effect. The question is asked—Are the observed effects on flames due to the simultaneous action of the two electricities, or does each act separately? It suffices, in order to solve the problem, to interpose, between the flame and the point, a diaphragm which is opposed to the establishing of the gaseous stream. It is easily ascertained, with plates of glass, sulphur, and gum-lac, that the beating down, the flattening action, is as energetic after as before their interposition, and it is also perceived with an earth-connected plate-conductor. This last arrangement constitutes a simple demonstration of the propagation of induction in a curved line. Thus the negative electricity attracts the flame which positive electricity repels. This result is by no means a contradiction to that which has been already established with reference to the mechanical effects of the electrical current. Faraday has, indeed, established in his "Experimental Researches" (11th series) that no instance presented itself in which he could give an absolute charge of one kind of electricity. The electric current, then, always exists, and, following the direction of its propagation, always produces the same effects of attraction or repulsion. The object of the author's investigations in this direction is, to use his own words,—"I hope soon to be able to make use of all the facts I have amassed to establish a satisfactory explanation of the stratifications of the electric light."

On a New Couple, specially prepared for the Application of Continuous Currents to Therapeutics.—Note by M. J. Morin.—Will be inserted at full length in our columns.

The Measure of the Electromotive Force of Batteries in Absolute Units.—By M. A. Crova.

Bulletino Telegrafico. Anno x. February, 1874.

Out of thirty-two pages small foolscap size, there are no less than twenty-three devoted to official and commercial regulations, five only to scientific subjects, and four to extracts from foreign periodicals and journals. None of the contents are new, or of interest to our readers.

Boston Journal of Chemistry. April 1, 1874.

The Practical Applications of Electricity.—Abstract of a Lecture delivered by Professor E. C. Pickering, at the Lowell Institute.—In the lecture, reference was made to the attempts to combine the wave theory of light and electricity by supposing that the vibrations of the ether which produce the phenomena of electricity are longitudinal, resembling those of sound, while the phenomena of light are produced by transverse vibrations of the same medium. The theory the lecturer advanced, though only provisionally, as the one that seems to answer all the requirements of the case better than any other, is that of a single fluid,—that this single fluid is the ether by whose vibrations light is produced; a body being charged positively when it contains an excess of ether, and negatively when the ether is deficient. The remainder of the lecture was upon electrical matters of an ordinary elementary nature.

La Nature.

A New Magneto-Electrical Instrument.—This instrument consists of a horse-shoe magnet, around the polar ends of the arms of which are wound the insulated wire in which the detachment of the armature induces a current. In order to use this current in place of that of an ordinary battery for exploding charges, a high tension is necessary, and is obtained by a simple and ingenious key which moves the armature. This key carries a small spring, which touches a screw. When the armature is removed from the magnet this contact is broken, but not instantaneously, as the parts touch until two-thirds of the motion is completed. One of the conducting wires is connected with the lever of the armature, the other with the screw; consequently the current caused by the sudden break is kept within the apparatus during two-thirds of the time of its production. This arrangement, which, at first sight, would appear to lose the effect of the greater portion of the current, really increases the potential, because the current which is delivered by the machine is no longer the magneto-electric induced current, but the extra current of the latter—in other words, a second induced current, which is produced at the moment of the rupture of the local circuit of the magneto-electric current. In round numbers, the attachment augments the current in the proportion of 1 to 5, and gives a spark which will explode ordinary hunting powder placed loosely between metal points.

Nature, Vol. ix., No. 233. April 16, 1874.

On Friday, April 10, M. Leverrier gave a *soirée* at the National Observatory of Paris in honour of the delegates of the French Scientific Societies. The exhibition of scientific instruments was very successful, and among them were many new electrical apparatus exhibited for the first time. No gas-light was used; an electrical lamp, by Perrin, being the only lighting medium.

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[*] See "Comptes Rendus," vol. lxxvi., pp. 1000 and 1351.

Lightning Conductors.—M. Colladon, the Geneva physicist, has published an essay on the subject of turning poplars into lightning conductors. He proposes to insert in the lower part of the tree a metallic rod in connection with the earth by a chain, so that the fluid cannot leave the tree to dart at any object placed within a short distance, which at present is very often the case.

No. 235. April 30, 1874.

The Russian Scientific Expedition to the Amu Daria was to set out on Monday, April 27. The expedition will be commanded by the Grand Duke Nicholas Constantinovitch, assisted by Colonel Stoletoff and Dr. Moreff, secretary. It will include twenty-five persons, whose work will be divided into four sections:—(1). The trigonometrical and topographical; (2). The meteorological section, which will construct two stations on the Amu Daria, at one of which hourly observations will be made of all the meteorological phenomena; (3). The ethnographical statistical section; (4). The natural history section.

Journal Telegraphique. Vol. ii., No. 28.

April 25, 1874.

General Telegraphic Statistics for 1872.—A lengthy *resumé* of statistics relating to the various telegraph systems of Great Britain and the Continent.

Meyer's Autographic Apparatus.—An illustrated description will appear in our columns at an early date.

Practical Formulæ Relative to Telegraphic Batteries. —M. Emile Lacoine.—Reserved for literal translation.

Scientific American, Vol. xxx., No. 18, April 18, 1874.

New Electric Disengaging Gear for Knitting Machines.—A novel and ingenious application of electro-magnetism to the knitting machine, the object being to stop the loom instantly and automatically whenever a thread breaks, is injured, or is of abnormal thickness, or when a needle becomes bent. Through certain combinations, we learn that one man can easily attend to four looms. The apparatus is in use in a large factory near Montargis, in France. A Gramme electric machine is there substituted for the battery, and supplies a current sufficient for 150 looms.

No. 19. April 25, 1874.

Improved Lightning Rod.—Electricity is best dissipated by conductors which present a large number of sharp edges; and if such angles extend throughout the length of the conductor, the current is received at any point as readily as at the pointed apex. It is on this principle that Mr. Minsen, of Indianapolis, has invented his improved form of lightning-rod. In addition to these advantages, it presents a variety of others, rendering it, it is claimed, a thoroughly efficient protection to any edifice upon which it may be placed. The rod is composed of copper wires and large galvanised iron wires, manufactured into a single rope. The copper wires are square in section, and are drawn perfectly straight, so that when they are twisted up in the rod an innumerable number of sharp edges is presented. The iron wire is galvanised not only to prevent corrosion but to increase its conducting power. The presence of two dissimilar metals in the rod also results in constant magnetic action, whereby its effectiveness and durability is enhanced, while its electric condition is preserved. There are no joints in the invention to become disconnected and thus offer points of escape for the current. The rod is perfectly flexible, and can be bent to any angle or curve, while it cannot be broken from its fastening by the effect of wind or jars. Its continuity, therefore, is a point of considerable importance, which, taken in connection with the conducting capacity of the metals used, the spiral form, and the other advantages already alluded to, combines to render the device theoretically one of much value.

Poggendorff's Annalen der Physik und Chemie.

No. 1, 1874.

An Investigation with reference to Bar-Magnetism.—M. Holz.—A number of steel bars were treated thus: —They were separately magnetised to saturation within a helix; a day or two after their magnetic moment was determined, and they were put in dilute muriatic acid; after remaining in it about twenty-four hours the moment of the bars (now become lighter through solution) was again determined. The bars presented a rough surface, and the dark mass (called by the author carburet of iron) had at the ends an appearance of threads parallel to the length, the iron mass lying round, like a liquid about a solid body. The numerical results are tabulated, and the following are the author's conclusions:—(1). The amount of magnetic moment of a steel bar, with reference to its quality, depends on the structure of the iron and the connected structure of the carburet of iron. (2). The magnetic moment for the unit weight (= 1 milligrm.) increases by removal of magnetised iron, decreases by removal of magnetised carburet of iron. (3). The particles of carburet of iron remaining behind after solution of the iron are magnetisable, and receive permanent magnetism. (4). The easiest permanent magnets may be obtained from the remains of dissolved iron masses, if these remaining particles are anew magnetised. The author further gives some results of observation as to the magnetic quality of several kinds of mineral graphite.

On the "Gliding" of Electric Sparks.—M. Antolik. —This new phenomenon may be most easily obtained by coating a glass bar with soot, and making an electric spark strike it. The "spark-streaks" (which mark the path of the spark) present two light parallel lines, and one dark line between them. The former evidently arise from a thrusting aside of the soot; the outer edges appear, in the microscope, somewhat thicker (they also show a number of dark and light triangles, evidently due to induction; the dark have their base, the light their apex, turned to the edge). In the middle black streak the soot seems compressed, and when water is poured on the rod the soot here remains, while it leaves the rest of the surface. And even when the last remnant has apparently been wiped off (with a cloth), the path of the spark may still be detected by breathing on the glass. The soot seems to have been pressed into the plate. Sometimes an inner white streak appears within the inner dark one. Some other appearances of similar nature are also described and figured.

Remarks on M. Roiti's Paper, "Is the Galvanic Current an Ether Current?" (See Tel. Journ., vol. i., p. 258). —M. Edlund.—Prof. Roiti's argument was, in substance, this:—The velocity of the ether, in a current, must (according to the experiment) be less than 200 metres in a second; but the velocity of propagation of electricity is otherwise shown to be several million metres in a second; hence it is very unlikely that the galvanic current consists of a passage of ether. Prof. Edlund, in reply, insists on the distinction between velocity of propagation of movement and velocity of the ether molecules themselves. Suppose a reservoir of slightly compressed air with a long tube from it, having a closed stopcock at the part where it leaves the vessel. The cock being opened, the air streams into the tube; but with whatever velocity it does so the motion is propagated with a constant velocity. The velocity of the stream may be 1 metre, it may be 2 metres, in a second; in either case the air-particles, at a distance of 330 metres, begin to move one second after opening of the cock (this being simply the velocity of sound in air). A like remark will apply to the ether. The velocity of propagation (v) of the motion depends on the elasticity and density of the ether, but is independent of the velocity (c) with which the ether particles are moved in the current. It is not strange, then, that M. Roiti should find the latter less than 200 metres, though v is several millions of metres. The author remarks on some other inaccuracies and defects in M. Roiti's research.

On Forth-carrying Discharges of Electricity.—Dr. Röntgen.—(See page 201).

Researches on Galvanic Polarisation and the Distribution of the Current in Electrolytes (first part).—M. Friedrich C. G. Müller.—Reserved for separate note.

On the Function of Magnetisation of different Iron Bodies.—Prof. Stoleton.—The author finds that M. Riecke's calculated numbers (in paper on the "Magnetisation of Soft Iron," *Pog. Ann.*, vol. cxlix., p. 433) quite confirm theoretical considerations. He points out that the quantity p (function of magnetisation of spheres) is little fitted to characterise the specific magnetisability of a substance: as in the case of spheres, the influence of nature of material nearly disappears before the influence of form. This applies generally to every body the dimensions of which, in all directions, are of the same order. The function of magnetisation of such bodies, obtained by experiments, will present much less variability than that of a thin bar or ring, a thin plate or shell, and may be nearly regarded as constant. But to infer from such constant values the magnetisation of a body of the other category would give inaccurate results. The influence of specific properties of the substance here becomes prominent, and must be taken into account. A knowledge of the function of magnetisation of a body of this kind is quite indispensable.

City and Commercial Notes.

The Spanish end of the Direct Spanish Telegraph Company's cable has been removed from Bilbao to Santander, and direct telegraphic communication with Spain by this route is now reopened.

The communication with the West Indies through the cables of the West India and Panama Telegraph Company is stated to be effected with great rapidity, the lines being in perfect order. A message sent from Demerara on the 28th of April was received in London on the same day.—*Times.*

On Saturday, the 2nd inst., the cable steamship *Hooper* left Gravesend with the Cables of the Central American Telegraph Company, Limited, manufactured by Hooper's Telegraph Works, to be laid between Para, Cayenne, and Georgetown, Demerara. When laid, these cables will connect the united systems of the Plato-Brazileira, Western and Brazilian, and West India and Panama Telegraph Companies, and will complete the chain of electric communication between the River Plate and the United States of America. The total weight of the cables now shipped on board the steamship *Hooper* amounts to upwards of 3900 tons, being the greatest weight of submarine telegraph cable taken on board any vessel at one time.

Messrs. Grant Brothers and Co. have announced that the half-yearly coupon, due the 1st May, on the Seven per Cent First Mortgage Building Bonds of the Western Union Telegraph Company will be cashed at the fixed exchange of 4s. per dollar, equal to £7 per coupon.

TELEGRAPH SHARE LIST.

Amount per Share.	Name of Company.	Amount paid up.	Closing Quotations.
£		£	May 12.
Stock	Anglo-American (Limited)	100	70¾—71¼
10	Brazilian Submarine..	All	7—7½
10	Cuba	All	7¾—8¼
10	Direct Spanish	9	..—..
20	Direct United States Cable	All	14—15
10	Eastern (Limited)	All	7⅛—7⅜
..	Do., New	..	101—103
10	Eastern Extn. Australia and China	All	7½—7¾
10	Globe Telegraph and Trust	All	6¼—6½
10	Do., 6 per cent Pref...	All	9¼—9½
10	Great Northern	All	10—10½
25	Indo-European	All	15½—16½
10	Mediterranean Extension (Limited)	All	4—4½
10	Do., 8 per cent Pref...	All	11—12
10	Panama and South Pacific	2½	..—.. dis.
8	Reuter's..	All	11¼—11¾
Stock	Submarine	100	220—225
1	Do., Scrip	All	2—2¼
10	West India and Panama	All	5¼—5½
10	Do., 10 per cent Pref.	All	10½—11
20	Western and Brazilian (Limited) ..	All	11—11½
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	105—107
10	Hooper's Telegraph Works	All	12—12½
50	India-Rubber and Gutta Percha ..	All	21—23
Cert.	Submarine Cables Trust	100	106—109
12	Telegraph Construction	All	30—31
100	Ditto Ditto 7 per cent Bonds	All	102—104

Telegraphic advices were received on Thursday, the 7th inst., from Rio de Janeiro, under date 18th April, with reference to the telegraphic cables of the River Plate and Brazil Telegraph Company (for which Messrs. Grant Brothers and Co. are London agents), which were in process of being submerged by the contractors, Messrs. Siemens Brothers, under the superintendence of the engineers of the Company, Sir Wm. Thomson and Professor Fleeming Jenkin. It appears that the first portion of the cable taken out by the steamer *Ambassador* had been successfully laid from Rio to Santos and Santa Catharina, and the steamer had returned to Rio. The remaining portion, taken out from England by the steamer *Gomos* (which had arrived safely), was to leave by that steamer on 21st April, to be laid from Santa Catharina to Rio Grande do Sul, and thence to be joined to the cables to Montevideo, which have been already submerged. From this it would appear that the completion of this important telegraphic line of communication may be looked for at any moment.

The total traffic receipts of the Great Northern Telegraph Company have been, during April, 1874, 354,815 francs, and in corresponding period of 1873, 241,251 francs. Total, 1874, 1st January to 30th April, 1,332,231 francs; corresponding period in 1873, 855,688 francs.

The traffic receipts of the Eastern Extension, Australasia, and China Telegraph Company, Limited, for the month of April, 1874, amounted to £16,670, and to £18,393 for the corresponding period of 1873.

The Eastern Telegraph Company's traffic receipts for the month of April, 1874, amounted to £30,766, and to £30,893 in the corresponding period of 1873.

The receipts of the Submarine Telegraph Company, for the month of April, 1874, amounted £8010 8s. 2d. For the corresponding month of the preceding year they were £8093 12s. 11d.

The number of messages (of twenty words) passing over the line of the Barcelona-Marseilles Cable for the month ending April 30, 1874, was 4064.

The tenth ordinary meeting of the Shareholders of Reuter's Telegram Company, Limited, will be held on Wednesday, 20th inst., at the Company's offices, 24, Old Jewry, for the reception of a report and balance-sheet from the directors, the declaration of a dividend, and the election of a director and auditors. The transfer books of the Company are closed from the 6th until the 20th inst.

The Eastern Telegraph Company (Limited) announces the opening for traffic of its new cable between Italy and Egypt *via* Zante and Candia. This company has now three cables working efficiently between Europe and Egypt, which is thus placed in direct submarine telegraphic communication with Great Britain, Spain, Portugal, Gibraltar, France, Malta, Italy, Greece, and Turkey.

The German Union Telegraph Company have declared a dividend for the year 1873 of £1 1s. 2d. per share of £15.

The Hamburg-Heligoland Telegraph Company have declared a dividend at the rate of 8s. 11d. per share of 100 thalers, or £15.

Messrs. C. J. Hambro and Son have announced the payment of the excess dividend on the Great Northern Telegraph Shares, at the rate of 1s. 8d. per share, on presentation of coupon No. 1 for 1872, and No. 2 for 1873.

Patents.

2327. A. Browne. (A communication from L. de B. O'Lawlor, of Paris). *Improvements in Electro-Telegraphy.* Dated July 4, 1873.—The features of novelty of this invention consist of certain new and improved contrivances for sounding alarms in houses and other buildings; also for transmitting messages from one house to another, and from one telegraph office to another, or between several houses and offices. The improvements are very complicated, and can only be explained by reference to the drawings accompanying this specification.

2401. C. E. Spagnoletti, of Paddington, telegraph engineer. *Improvements in Working Railway Signals by Electricity.* Dated July 11, 1873.—This invention refers to a combination and arrangements of electro-magnets in connection with certain mechanism whereby the actual signals on the line are worked at any distance.

2430. G. M. Phelps, of Brooklyn, New York. *Improvements in Printing Telegraphs.* Dated July 14, 1873.—Three electro-magnets in the main line circuit are used; the pulsations are of alternating polarity to vibrate a permanent magnetic armature between two of the magnets. The third magnet acquires sufficient energy, when there is a pause, to let off the printing mechanism, which is a revolving shaft with crank pin to give impression and to feed the paper. A unison mechanism on each instrument stops the revolution of the type wheel to bring them into harmony, and an impression pad is shifted from one position to another, where two type wheels are used.

2545. H. B. Greenwood, of Middlesex. *An Improved Method of and Apparatus for Applying Electricity to Locks for Operating and Securing the Same.* Dated July 25, 1873.—My said invention relates to the application of electricity to locks in such a manner that the lock when properly secured can only be opened by the proper key, and moreover any attempt to manipulate the lock by means of another key or any other instrument will be indicated by the condition in which the lock is left by such attempt. My said invention relates first to the peculiar arrangement of two magnets and circuits in combination with the lock, and with a voltaic battery; secondly, to a contrivance for insulating the pin or other part of the lock with which the key is in contact when inserted into the same from the other parts of the lock; and thirdly, to the peculiar construction of the keys for operating the said locks.

2554. Sir Samuel Canning, of London, and E. J. Mayor, of Hammersmith. *Improvements in Telegraphic Apparatus.* Dated July 26, 1873.—This invention relates more particularly to pneumatic telegraphic apparatus suitable for use in conveying signals in houses and manufactories, on board ships, on railways, in railway trains, and for other like purposes. According to one arrangement of pneumatic telegraphic apparatus it is proposed to employ for effecting the compression of the air necessary for transmitting signals through tubes a cylinder and piston communicating with the transmission tube or tubes the mouths of which we prefer to make conical. Outside and concentric with this cylinder and piston, there is a second cylinder and piston of annular form, the annular piston being connected with the internal piston so that the two shall move together. One or more holes are made in the sides of the inner cylinder so as to communicate with the annular cylinder, and other holes are made in the annular cylinder communicating with the atmosphere. These holes serve to equalise the temperature of the air in the cylinder and transmission tube or tubes, as when the apparatus is at rest there is a free communication between both the cylinders and the atmosphere. Or in lieu of using inner and outer cylinders each provided with its piston, two tubes may be employed, the one sliding within the other like the joints of a telescope, air holes being provided for establishing a free communication with the atmosphere when the tubes are drawn fully out, but which communication is closed on forcing inwards one of the tubes in the act of compressing the air to force it along the signal tubes. Another arrangement of apparatus consists of a mode of constructing a pneumatic indicator or telegraphic instrument in such a way that the order shutters or tablets shall be held in the required position without depending on any valves or stopcocks or on the maintenance of any pressure in the pipes. Also of such an arrangement of the air-compressing cylinders for making the above, as that one movement of the lever of the communicator shall cause an inflation and collapsing action in different air chambers of the indicator at the same time. Also in so arranging the bell and shutter action of the indicator as that one air chamber shall give the movement necessary both to ring the bell and display the signal, thereby giving an increase of power by reason of the air not having two air chambers to expand into as heretofore. This invention further comprises an improved pneumatic bill for long distances.

2568. T. Walker, of Chelsea, Middlesex, electrician. *Improvements in Electrical Apparatus Applicable to Telegraphy and other Purposes.* Dated July 29, 1873.—The first part of this invention consists in arrangements applicable to telegraphic and other purposes, whereby electrical currents can be advantageously transmitted through conducting wires, whether the same are entirely or imperfectly insulated or are entirely uninsulated, and whether they are submerged in water, laid underground, or suspended in the air. For this purpose any desired number of permanent magnets or of pieces of iron or steel or electro-magnets are placed in connection with the transmitting and receiving ends of the conducting wire, and if desired and practicable at intermediate parts thereof, and an electric current from a galvanic battery or other source of electricity is sent through the circuit. Another part of this invention consists in using as a relay, register, or translator, an electro-magnet, the iron core of which passes only partially through the coil, the other part being left hollow, and a permanent magnet properly adjusted to work therein. When a current passes, the magnet is drawn in or repelled. A permanent magnet may be substituted for the iron core, and iron for the armature; or the core may be fixed and the coil made movable, or the coil may be constructed without any core and the magnet adjusted to work freely therein.

2576. W. H. Davies and F. H. W. Higgins, both of

Cornhill, London. *Improvements in Electric Telegraphs.* Dated July 29, 1873.—In the instrument described in this provisional specification, a double type wheel with 60 characters is employed—15 currents complete its rotation—printing can take place whether the current is off or on, and one or other side of the double wheel can be employed at pleasure. The escapement is peculiarly constructed to prevent over running. An improved inking roller is used and vibrations are checked by a pad of sponge rubber. The transmitter has a vibratory governor in place of a fly to control its actuating train. The relays are provided with double contact points and a condenser is used in connection with them.

2577. A. Jaynor, of the Strand, Middlesex. *Improvements in Pneumatic Telegraphic Apparatus for Transmitting Messages or Signals for Ships, Hotels, and other Similar Purposes.* Dated July 30, 1873.—This invention relates to improved arrangements in the construction of pneumatic telegraphic apparatus suitable for transmitting messages or signals on board ships, or for hotels, mines, or other like purposes.

2588. J. Mathieson, of West Ham, Essex, electrician. *Improvements in the Construction of and in the Mode of Firing Torpedoes.* Dated July 30, 1873.—This invention relates, firstly, to a novel arrangement of mechanism for closing and breaking the circuit of electric batteries connected with torpedoes or submarine mines; secondly, to an improved mode of firing torpedoes.

2618. F. A. Palmer, of New York. (A communication from C. Gaume, of New York, U.S.A.) *An Improvement in Electro-Magnetic Engines.* Dated August 2, 1873.—The feature of novelty of this invention consists chiefly of an improved construction of the armatures whereby "pull back" or retardation is obviated. The armatures consists of a central bar attached at its centre to the face of the wheel and having cross-heads formed upon them about midway between its centres and ends, the said crossheads having short bars formed upon their ends parallel with the central bar, and the ends of which project to equal distances upon the outer and inner sides of the said crossheads. The aforesaid wheel revolves in bearings in the frame of the engine, and the said armatures are operated in connection with horse-shoe magnets having coils connecting with a battery and with suitable appliances for successively closing and breaking the circuit.

UNITED STATES.

143,341. M. Gally, Rochester, N. Y. *Multiplex or Interval Telegraph.* Dated September 11, 1873.—Through automatic circuit closers at the various stations synchronously driven. Definite intervals are allotted to the instruments for communication, so that the wire may be worked to its full capacity by using the intervals necessarily occurring in ordinary transmission. An automatic circuit closer having a group of conductors representing the short dashes of a telegraphic alphabet, and sufficient in number to fill a space equal to the length of the longest letter of such alphabet, in combination with transmitting keys, each key connecting with such a selection or combination of the conductors of said group as to produce any letter of the alphabet indicated by such key. In a line of instruments arranged for multiplex transmission by allotting to different instruments different intervals of time for operation, the combination, with a transmitter or receiver, of devices for changing such transmitter or receiver from one interval to another, thus setting the instrument to any unemployed interval desired. A circuit closer made of conductors separated by non-conducting material, having non-conducting bearings for the connector or connectors, which bearings are separated from the conductors by intervening trenches. In combination with an automatic circuit closer a receiving conductor or conductors, occupying a space equal to a group of transmitting conductors, from which group combinations are made for producing different characters. The combination, with a transmitter and receiver arranged for a multiplex system of intervals, of devices for securing one interval to the transmitter while another is being used by the receiver. The combination of an armature with a number of magnets operating therewith, substantially as specified. The armature of a magnet, in combination with a device which applies positive mechanical force for the return movement of the armature, after it has been attracted by the magnets. A magnetic indicator, consisting of a wheel moved by slight friction power, and stopped or retarded for its indications by means of a magnet. The combination, with a telegraphic transmitter or receiver, of a relay or repeater, which gives its repeated pulsations by means of the return movements of its armature, which impulses are measured by the duration of such return movement.

145,997. C. Fox and E. G. Heston, Gap., Pa. *Telegraph Insulator.* Dated August 20, 1873.—An annular glass insulator, slotted in its upper face for the wire, fits over a stud, and rests upon a shoulder on the supporting bars. A shed cap screws down upon the stud. The combination of the nut-like cap C with its sheltering base to cover, clamp and protect the annular slotted insulator G B, when the latter rests upon the shoulder *a*, and the former receives the screw end D of a vertical shaft or support, A, the whole arranged in the manner shown in a diagram.

146,421. J. B. Andrews, N.Y. *Electric Ship Alarm.* Dated November 6, 1873.—Deviation of compass operates a circuit closer controlling an alarm. In combination with a magnetic needle or bar, suitable means adapted to be influenced by any change in the relative position of said needle with the ship, and an alarm device for denoting such change.

146,444. H. Fontaine, Paris. *Electro-Magnet.* Dated October 2, 1873.—A magnet formed of a series of thin, flexible metallic blades, strips, or their equivalent, assembled and bound together by pieces of copper, soft iron, or malleable cast iron.

146,641. R. M. Billings, Townsend, Pa. *Burglar and House Alarm.* Dated June 27, 1873.—Battery and alarm connected to three circuits, viz.,—Burglar, connected to doors and windows; day, to bell pull; and one to a clock for an alarm at a determined time. Gong and hammer both adjustable.

To Correspondents.

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